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ABSTRACT

The goal of the Toledo, Ohio, Support Teacher Programs has been to improve the learning of math and science concepts at the junior high school level. This goal involves some basic changes in the way teachers interact with each other and with their students. The greatest changes have been in the movement away from the lecture-note-taking-test-taking cycle and in overcoming teaching isolation. The study of research materials dealing with misconceptions and conceptual understanding, especially the work of J. Nussbaum (1985) had a particularly strong impact and led the teachers to emphasize the exposure of misconceptions in their own classrooms. Because traditional approaches had not worked, the teachers realized that they needed to become better listeners; to accomplish this they adopted the following techniques from the literature: (1) using better questioning methods, working on student and teacher listening skills, making the students do the work without supplying the "right" answer; (2) concept mapping to improve understanding; (3) cooperative learning; and (4) making students write to enhance sense-making. Benefits observed from the use of these techniques, each of which is described in detail, were the following: (1) students become actively engaged in constructing their own meaning; (2) positive interactions occur among students; (3) students display a positive attitude about science; (4) students take more responsibility for their own learning; (5) students feel free to question and probe in a nonthreatening atmosphere; (6) students feel free to take more risks; (7) students self-esteem is enhanced; and (8) students active involvement results in fewer discipline problems. The program continues, and while progress is slow there seems little doubt that a teaching pattern where teachers talk less and listen more will greatlyy enhance student learning. (KR)

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THE TOLEDO SUPPORT TEACHER PROGRAM

USING WHAT WE ARE LEARNING ABOUT LEARNING: TALKING LESS AND LISTENING MORE: A MEANS OF HELPING STUDENTS MAKE SENSE OF SCIENCE

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and

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The main goal of science teachers should be to allow their students to make sense of science concepts. How they go about this task and what they actually teach may vary greatly from one teacher to the next. Many teachers use the traditional **lecture - note taking - review - test** cycle that is so common in junior high, high school and college classrooms. The reasoning behind this traditional style is generally : "this is the way that I was taught during my formal education, and I obviously 'learned' well.

Three NSF Studies (Derose, J.V.: Lockard, J.D. and Paldy, 1979) conducted in the late 1970's characterized science teaching practices. These reports indicate that science teaching has remained relatively unchanged since the 1950's. These teaching practices include:

1. The predominant method of teaching was with the teacher in control of discussion and recitation, supplementing the lesson with new information through lecturing. The key to new information was the textbook.

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2. The secondary school science curriculum was ordinarily organized with the textbook at the core. The textbook determined the course content, mode of instruction, and evaluation. The most significant curriculum decision that the teacher made was the choice of a textbook. The teachers attempted to cover all of the content of the textbook, mostly in the order determined by the book, with instructional aids provided or suggested by the teacher's guide.

Through research done as part of the Secondary School Science Project, conducted with the support of the Institute for Research on Teaching at Michigan State University, and in work done jointly with Kenneth Tobin at Curtin University of Technology in Perth Australia, James Gallagher and his colleagues reported that:(Tobin K., Gallagher J. 1987)

> ...textbooks are at the central position in most science classes. The textbook is the curriculum and many teachers follow the text in planning their lessons, in assigning homework, and in testing their students. The knowledge of science vocabulary receives the major attention, therefore, the covering of the text's content and the teaching of scientific terminology become the main goals of teaching science. This contributed to low standards of academic performance in science and provided relatively little challenge or practical utility to many students.
>
> ...the general teaching format used by most secondary science teachers was to present scientific information orally, using specific aids such as handouts, references to the text, chalkboard diagrams, notes, and films (which were not necessarily used to enhance what was being taught, but often were a diversion from the main line of teaching). Students were usually given homework assignments with some class time allocated to it. Homework assignments tended to be end of the chapter questions from the text-book or worksheets prepared by teachers. The next day the students and teacher would go over the homework, frequently question by question, to review correct answers and to help students who may have had difficulty. Every few days, students were given a quiz and every 2 to 3 weeks, a review

> session was conducted and unit tests were given. Typically, tests were comprised of a variety of objective items including matching, fill-in the blank, true-false questions, and labeling diagrams also was a part of many tests. Whole class instruction predominated.
>
> A feature absent in nearly all classes was the opportunity for students to construct meaning independently from reading, films, labs, etc.. Teachers rarely asked questions orally or in written form that would foster 'making sense' for themselves. In most cases, when a student asked a question that showed that he or she was trying to 'make sense' of the ideas or relationships present in class, teachers would exhibit a pattern of direct answers, instead of turning the question back to the class by saying 'what have we learned that can help answer this question?'. Similarly, teachers did not ask questions to help students see relationships between new ideas and their existing knowledge or daily experiences. (Gallagher, 1989)

The above descriptions, of how many science classrooms operate, probably is best explained by how many teachers view their roles. It was found (Bettencourt and Gallagher, 1990) that numerous secondary science teachers see themselves as "presenters of scientific information." They frequently defined their positions with an added statement:

> "My job is to present the information, the students' job is to learn it. The good students will do it and the rest won't."

The scenario presented in the work cited above pretty well describes where the four science teachers who are involved in the Toledo Support Teacher Program found ourselves in our teaching practice 3 years ago. All of us were concerned with the 'learning' that was going on in our classrooms. We were all veteran teachers, and we were all feeling some degree of frustration with the results that we were getting from our students. The frustration stemmed from the fact that with all of the time that we spent planning,

teaching, and reviewing, we were still not seeing students understand or make sense of science concepts. They could not explain concepts beyond a memorized textbook definition. Interest in science was lacking and students often commented that science was too hard or boring, or that they just didn't understand it.

This idea is supported in an article written by Robert Yager: (Yager, Science Teacher, 1986)

> Why do 90% of the students that we teach grow into adults who pay no attention to science? And what should we as science teachers be doing about it? Not only do students lose interest in science as they progress in school, but students are less interested in science after a science course than they were at the beginning of the course. AND STUDENTS RETAIN ALMOST NOTHING OF WHAT WE "TEACH" THEM. Although science teachers often identify a variety of goals for their science courses, often their only goal in fact is to get students ready to study more science. And yet there is no evidence that teachers at the higher levels ever recognize the preparation that their students received at lower levels. Why the emphasis on science content at every level? No one has even identified specific concepts that students need before proceeding to the next academic level. And yet science teachers continue to emphasize terms, language, and laws. We continue to test for mastery even when it is shown that success on Friday quizzes is temporary learning. We continue to push mastery of "our" science (that found in the text) even though the approach decreases student interest, does not affect concept learning, and does not help or motivate students

The goal of the Support Teacher Program has been to improve learning of math and science concepts at the junior high school level. This goal involves some basic changes in the way teachers interact with their students and with each other. The changes require teachers to pull themselves away from traditional classroom

practices (such as lecturing, conveying factual information, etc.) and to become more reflective about what we are doing in the classroom and why we are doing it.

Since becoming involved in the Support Teacher Program, we have had to change our practice considerably. The greatest change has been the movement away form the traditional **lecture - note taking - test taking** cycle. The realization that this method by itself is ineffective as a teaching tool had been the source of our frustration for quite some time. However, due to a lack of exposure concerning research that dealt with alternative methods of teaching science, we continued doing the same old thing and getting the same frustrating results.

Three major areas of our training as Support Teachers involved: 1.Improving our own teaching practices. 2.Working with our peers to improve their teaching practices. 3.Reading research material that dealt with alternative teaching practices. This last area was the "hook" that really got our attention and eventually led to the change in our vision of how students learn and as a result, how we must change our teaching practice.

The research performed by such people as Nussbaum, Driver, Osborne, Cosgrove, Roth, and Anderson that deals with misconceptions and conceptual understanding has had the greatest effect on the Support Teachers and has caused us to begin thinking about how we could alter our teaching. Nussbaum's work that deals with the particulate nature of matter in a gaseous state was one that none of us will ever forget.(Nussbaum 1985) It was very enlightening to us to see how students responded by way of drawings to the

question: "How will the gas molecules behave in a flask if you remove half of them?" The drawings that they produced uncovered many misconceptions concerning the particulate state of matter. What was even more interesting was our own personal response to the same Nussbaum question. We also were unsure of the answer, and we were all veteran science teachers.

This piece of research as well as many others caused us to begin questioning our own teaching techniques, as well as misconceptions that we may have concerning some basic science principles. Had we been contributing to our students' misconceptions over the past twenty years?

Our next step was to check for misconceptions in our own classrooms. This was done by having the students respond in writing to an open-ended question that dealt with a previously "covered" science topic. One of the topics that had been covered recently was menstruation. When asked what they now thought menstruation was, many interesting answers emerged. Many of the answers indicated that the students had not made sense of the concept and did not fully understand it. Another disturbing observation was that most of the students had done quite well on the traditional multiple choice test that covered this topic, and had successfully completed several homework assignments that dealt with the topic. We were temporarily amused by one students' answer, relating that menstruation was "when the hormones kicked in". The amusement was short-lived, because what we had painstakingly planned for, taught, and tested for resulted in the student being able to make little sense of the concept. Believe it or not, this is the first time that this

was apparent to us. (Luallen, J. class activity 1988)

These findings and the subsequent readings on misconceptions, produced much discussion about students' learning and our teaching methods. From these discussions we came to realize, as Support Teachers, that we needed to be aware of students' prior knowledge (and misconceptions) before instruction begins. The task during instruction was to help students make sense of the topic, and upon completion we should be able to assess their learning and understanding in a meaningful way.

In order to perform these tasks we had to become aware of how students learn, and then incorporate new teaching techniques into our practice. These new techniques would aid the students in construction of knowledge and sense-making.

Because dealing with student misconceptions has become a major component of our program, we (as support teachers) needed to find ways to expose these misconceptions. The traditional teaching methods had not worked, i.e., lecture, take notes, review, test. This is when we began to realize that we needed to become better listeners. We began having our students write much more than they did in past years, and our classroom questioning techniques began to change. The old method of memorizing facts, giving textbook definitions, accepting only one word answers to questions posed during class discussion, giving only objective types of test questions, etc., did not provide us with enough material to diagnose what the students really know. When we began having our students discuss problems in much more detail, and write out what they really think they know about a topic, we began getting valuable diagnostic

information concerning their real understanding of scientific concepts.

During the past three years, the support teachers have been exposed to numerous techniques that have aided us in "getting at" student misconceptions and helping students make sense of science concepts. Some of these techniques are not new, but they were new to us. Prior to the Support Teacher Program, we had not had the time to search the literature to find out what researchers were learning about learning. We were now given the time, and that alone gave us the inspiration to find out as much about the learning process as possible. Some of the techniques that we were exposed to were:

1. UTILIZING BETTER QUESTIONING TECHNIQUES, WORKING ON STUDENT AND TEACHER LISTENING SKILLS, AND MAKING THE STUDENT DO THE WORK WITHOUT CONSTANTLY PROVIDING THEM WITH THE "RIGHT" ANSWER.
2. CONCEPT MAPPING TO IMPROVE UNDERSTANDING.
3. COOPERATIVE LEARNING.
4. MAKING STUDENTS WRITE TO ENHANCE SENSE-MAKING.

In all of these techniques, we are working on getting more oral and written feedback from the students. These techniques force the teacher and student to become better listeners and readers, and allow the student to become a more active participant in the learning process. Elaboration of these techniques will give you a better feel for what the Support Teacher Program has allowed us to do:

1: **QUESTIONING TECHNIQUES, LISTENING SKILL IMPROVEMENT**- We have been involved in utilizing questioning techniques that would allow students to share their knowledge with the teachers and classmates. We are encouraging students to listen to one another and to "hitchhike", i.e., build upon or argue with another person's ideas. In order to do this the tone has to be set early in the year that allows for a non-threatening atmosphere during class discussion and group work. The students must be made aware of the fact that even a wrong answer is valuable, and at the very least it showed us that they were thinking. Questions that the student asks are generally given back to them for elaboration, or thrown out to the class for a response. In the past, we would have simply given the answer to the student and moved on. We saw our role as "providers of information". We now realize that when a student is provided with a "quick" answer very little learning takes place. It is an efficient way of covering a topic, but the learning that takes place is disappointing. We must not rob the student of the opportunity to make sense of a concept by giving him or her the "right" answer. A typical classroom discussion might sound like this:

"Raise your hand if you can explain the relationship between the circulatory system and the respiratory system." (typically 6 or 7 hands go up out a class of 30)
"Good! Now those people with your hands up, share your answer with the students on either side of you."
(wait about 1 minute for the sharing to take place)
"O.K., now raise your hand if you know the relationship between the circulatory system and the respiratory."
(you should now have at least half the class with their

hands up)
"That's good. Now let's do it one more time. Tell the students in front of you and behind you what you think the relationship is." (at this point the room should be buzzing with discussion concerning the relationship; everyone in the class is engaged in the discussion and it is not simply a dialogue between one student and the teacher)
"For the last time, raise your hand if you think you know the relationship between the circulatory system and the respiratory system."(most of the class will now have their hands raised) (Leonard, D. Gallagher, J., n.d.)

Check the answer by having one or two of the students explain the relationship to another student so that the entire class can hear the explanation. Have these students direct their explanation to another student and not to the teacher. This is a good time to verify the answer by having the rest of the class raise their hands if they agree with the answer. You may also get some disagreement, which is a healthy sign that sense-making is going on.

This format of discussion keeps the students involved in "talking science". It changes the teacher's role from one of provider of answers to a person who facilitates the thought process involved in making sense of an idea.

If you are saying to yourself at this point, "this process takes a lot of class time", you are right. This kind of questioning technique does not allow a teacher to "cover" as much content as was traditionally covered in science class. However, the atmosphere of cooperation, responsibility for their own learning, and active engagement in the sense making process will be of much greater value to these students, than for example memorizing all of the parts of the circulatory system. It is also surprising how much factual material will be picked up by a student in the process of trying to make sense of a concept.

Wait time was another technique that we began working on in connection with our questioning technique. Much has been written about the merits of using wait time to promote student understanding. It is a technique that is easy to forget, especially within the framework of our 42 minute class periods in the junior high. Time

is something that we all value greatly. With time in the classroom, being such a precious commodity, many teachers feel that we cannot afford to waste any of that time by having moments of silence during class discussions to allow a student to construct a meaningful answer to a question. What we all need to keep in mind, is that if a question is asked that requires more than a one word answer, the student needs some time to mentally put together a meaningful answer. Wait time should also be provided after an answer is given to allow the class to assimilate the answer and to see if it makes sense. Generally, in our haste to get everything "covered", and to make all of the right connections or to have the students make all of the right connections, we rarely give the students enough time. We need to give them a chance to reflect about what they have said, to formulate answers that make sense, and then to respond orally to the question. When we don't give the students the time they need, we are taking away that opportunity to construct meaning and to make sense of science concepts. These are the very things that we ostensibly have as our major teaching goals, but because of a self-imposed time constraint, we handicap our students' ability to understand science.

2. **CONCEPT MAPPING** - This technique has been around for many years, but the support teachers were first exposed to it three years ago. It is just one more method that helps teachers help students, make sense of science concepts. Concept mapping results in the student connecting basic science concepts to the ideas related to the concept. It allows the student to mentally and visually

construct meaning. The technique can be used in many ways: A teacher could assign a map construction at the beginning of a unit. This could be done as a means of giving the student a chance to use resource materials to find out as much about the concept as possible. This has proven to be an effective way to introduce a concept.

A more effective use of this technique might be as a culminating activity. Give the students the assignment of listing all of the ideas that they can think of that are related to the concept that they have been studying. When they come in the next day with the list, have them get into their cooperative groups and share their list with their group members. The class assignment would then be to construct one concept map per group, using as many of the related ideas as they can.

Concept mapping is also a useful tool for teachers to use when they are planning a lesson. It will help them visualize problems that might develop in a student's mind concerning a particular concept. It also will give them a good idea of the kind of assessment that they will get involved with when they are finished with the unit.

3. **COOPERATIVE LEARNING** - Cooperative learning has given us an opportunity to work on concept development and at the same time work on some important social skills. Such skills as listening, taking turns, staying on task, avoidance of verbal "put downs", and keeping track of time are all examples of social skills that students become aware of during cooperative learning activities.

When the students learn that they will be held accountable, both as an individual and as a member of a group, cooperation within the group improves.

During group work we have all been impressed by the fact that even though the noise level is higher, we are hearing students talk about science. This is in contrast to what might have gone on in the past in our more traditional classroom setting. In the past the greatest percentage of "science talk" was coming from the teacher. Students were often engaged in off-task behaviors such as day-dreaming, talking to classmates concerning their own agenda of non-science topics, and creating discipline problems. Cooperative learning has afforded the student the opportunity to engage in science discussion in a fairly non-threatening atmosphere. It is a departure from the traditional didactic classroom discourse that occurs between a teacher and one student.

4. **WRITING TECHNIQUES USED TO ENHANCE SENSE MAKING** - Student writing is another method of "getting at" misconceptions and trying to make sense of concepts. Prior to the Support Teacher Program, the extent of student writing in our classes amounted to one word or short phrase written responses to objective types of quiz or test questions, writing out vocabulary lists and definitions, writing the answers to end of the section or end of the unit review questions, and copying notes from the blackboard or overhead screen.

Writing is now incorporated into our everyday lessons as a technique to allow students to compose and organize their thoughts, and to reflect on a given concept. Students are expected to make daily entries in their notebooks or journals. We are using many more essay-type questions on quizzes and tests. One of our favorite techniques was introduced to us by the Michigan State personnel who are involved in the program. lt is called a "mindstretcher". (Gallagher, Jamison, Cline 1990). A mindstretcher can be used in a variety of ways: 1.At the beginning of a class to serve as a bridge from one day's lesson to the next. 2.To check on students' prior knowledge concerning a particular concept. 3.To check for misconceptions. 4.As a class opener. This allows the teacher to immediately engage students in "thinking science", and helps to eliminate the off-task behavior that often accompanies the start of a class period.

A technique that one of the support teachers uses that is a spin-off of the mindstretcher is something that is referred to as a "Were You Listening" activity. After a class discussion of a topic or concept (during which the teacher has attempted to work on listening skills), the teacher gives each student a piece of paper entitled "Were You Listening". A question is then asked that is related to the topic that was previously discussed. The question requires the student to supply more than a one word answer and preferably should require a short paragraph.

Once the students realize that this technique is going to be used frequently, their listening skills improve. As a bonus, they are also improving their writing skills. It is just one more opportunity for the student to organize his or her thoughts and to reflect and make sense of what is going on in class.

Some of the benefits that we have seen in our classrooms are a direct result of the techniques mentioned above. They are:
1.They allow students to abandon their traditional passive roles in the classroom and to become actively engaged in constructing their own meaning. For example, as we have stated previously, kids are "talking science" during their group activities. We are attempting to have the students talk to one another, share ideas, and construct meaning by getting input from other class members. We are also providing our students with opportunities to do hands on activities on a regular basis. These activities could be anything from culturing yeast cells to constructing cell models.
2.Positive interactions between students. We have found that once you have established a working atmosphere in the classroom, the students become more and more willing to help on another. They begin to depend on one another. This idea of positive interdependence has been well documented by David and Roger Johnson.(Brandt, R.S.,Educational Leadership, 1989) However, this "helping" atmosphere does not develop without constant reminding. Students must be made aware that they are accountable to themselves as well as to other members of the class. Once this atmosphere has been

established, we have observed "friendly" disagreements between students and much more constructive behavior. The absence of verbal "put downs" is a nice spin-off of this helping atmosphere.

3.Students display a positive attitude about science, i.e., "Science is fun this year." "When can we do group work again?" "I like it when we get to solve the problems together."

4.Students are actively engaged in taking more responsibility for their own learning and understanding, as is evidenced by both written and oral work. There is a marked improvement in both the quality and quantity of writing done by the students. A comparison of work that students have done in September to the work that they are doing by the end of the year is evidence of this. By the end of the first nine week quarter, students are aware that one-word answers are not acceptable in oral or written work. They are constantly being asked to elaborate or add to whatever they are attempting to explain. Once the students realize that a textbook definition by itself is not an acceptable explanation, they begin to work on construction of meaning for a given concept or idea. By mid-year many students have shown improvement in both their written and oral work.

5.Students have the freedom to question and probe a given science concept in a non-threatening atmosphere. We discourage verbal "put downs" from the first day of classes in the fall until the last day of classes in the spring. When students realize that others will not make fun of them when they come up with a "wrong" answer, they become much more willing to participate. We encourage students to reflect on statements that they make in class or others

have made. The idea that there is more than one right answer to any given problem is foreign to many of our students. Once they know that we are as interested in the thinking process as we are in the answer, students become more responsive. This responsiveness on the part of the student, is what provides the teacher with the opportunity to reflect on what is really going on in the students' mind. This is when we become aware of the misconceptions that we discussed previously, however, this only happens if the student feels "safe" in responding.

6.Students are able to take more risks once the learning atmosphere has been established. This risk-taking is obviously closely connected to the non-threatening atmosphere which we just discussed. When they know it is O.K. to be wrong, and when they know it is O.K. to disagree with other students or the teacher, they become more willing to express their thoughts. This risk-taking is also helped by the fact that they know that they can get some help from other classmates or group members.

7.Students' self worth and esteem are enhanced by their active participation and personal investment in the problem solving that occurs in the classroom. You, of course, have to be there to see this happening. Many students who begin the year with a timid attitude toward speaking and writing, show great progress in both areas by the end of the year.

8.Student engagement and active involvement in constructing meaning, results in fewer discipline problems. Allowing students to become active members of the classroom by involving them in such things as group work, or allowing them to interview one another about

their thoughts on a specific problem gives them the opportunity to become really involved in the learning process. This engagement in the process is something that they enjoy and possibly see as useful. It goes way beyond the typical seat-work, fill in the blank, non-thinking type of activity that they are involved with during so much of their school life. These traditional techniques do engage the student, but only until he or she can find something that is more interesting to do. This is not difficult for them to do, and the consequence for the teacher is generally a discipline problem. Constructing meaning is a difficult process. It is a challenge for both the student and the teacher. However, once the student has gotten involved in this constructive process they do not find as much time for off-task behavior. The result however is not just engagement of the student for the purpose of controlling their behavior (as is the case with much of our seat work), the result is real learning accompanied by better behavior.

Thanks to the research that provided the "hook" for a new vision and the new techniques that we have been working on, junior high school students in Toledo, Ohio are being given the opportunity to make sense of science. The program continues. Once the "vision" has been acquired, we have found that it takes a long time for teaching practices to change. Even after three years in the program, we are still trying to have our practice catch up with our vision. Is it possible that the vision and the practice never catch up with one another? Maybe this is what "keeps us on our toes".

A parallel problem that is evident involves teaching at the elementary and high school levels. The program now exists only on the junior high school level. When the students come to us, many have never been exposed to science, and those that have are full of misconceptions. When they leave us they have hopefully gotten a taste of what it is like to understand and make sense of concepts. Most high school classrooms however, are very traditional. Think of the possibilities for a scientifically literate citizen, if the Support Teacher Program could be extended both into the lower and upper grades. From our experience it would be a small step in the right direction.

Progress is slow, and teachers need constant nurturing and support. This support will allow them to change their teaching techniques for the better and improve their interactions with students. We are convinced that if we become involved in a teaching pattern where we talk less and listen more, student learning will be greatly enhanced.

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